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HOT IN-PLACE RECYCLING WITH AN INTEGRAL HOT MIX WEARING COURSE PLACED WITH RSR EQUIPMENT

(CONSTRUCTION REPORT)

MATERIALS INFORMATION

ENGINEERING MATERIALS OFFICE

HOT IN-PLACE RECYCLING WITH AN INTEGRAL HOT MIX WEARING COURSE PLACED WITH RSR EQUIPMENT

(CONSTRUCTION REPORT)

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BACKGROUND

An Ontario contractor, Road Surface Recycling (RSR) of Milliken, developed a machine to hot recycle asphalt pavement insitu and place a new hot mix overlay in a single pass. RSR claimed the ability to heat and scarify the existing hot mix pavement up to a depth of 50 mm, add a rejuvenating agent to restore the asphalt cement to the penetration of new mix and place a thin hot mix overlay all in one pass. RSR claimed the process to be more economical than the Ministry's current method of partial-depth cold milling, recycling in a hot mix plant with virgin materials and placing a 50 mm lift of recycled hot mix.

In order to provide RSR an opportunity to demonstrate the technical capabilities of the equipment, a 4.6 km section of Highway 3 between Jarvis and Simcoe on Contract 87-08 was dedicated for a trial.

ORIGINAL PAVEMENT CONDITION

Highway 3 at this location is a rural two lane highway with an AADT of 4000. It was re-constructed under a 1974 contract and had several long hot mix patches added in subsequent years.

The existing pavement structure consisted of an average of 229 mm of hot mix over a variable depth of granular material (150-450 mm). The main form of deterioration was moderate loss of coarse aggregate throughout with frequent areas of severe ravelling. Slight wheel track rutting occurred throughout with slight distortion in the areas of severe ravelling. Both half- and full-pavement width transverse cracks occurred throughout at 3 to 20 metre spacings. Single and multiple longitudinal wheel track, mid-lane, center-line and pavement edge cracks existed throughout.

The penetration of the asphalt cement recovered from the surface course mix averaged 24 penetration.

REHABILITATION STRATEGY

The contract was originally designed for partial depth cold milling at various depths (typically 45 mm), and recycling through a hot mix plant at a ratio of 49% reclaimed asphalt pavement (RAP) to 51% virgin aggregates.

The design also required the existing 3.2 m wide pavement to be widened to 4.0 m which would include a 0.5 m partial paved shoulder.

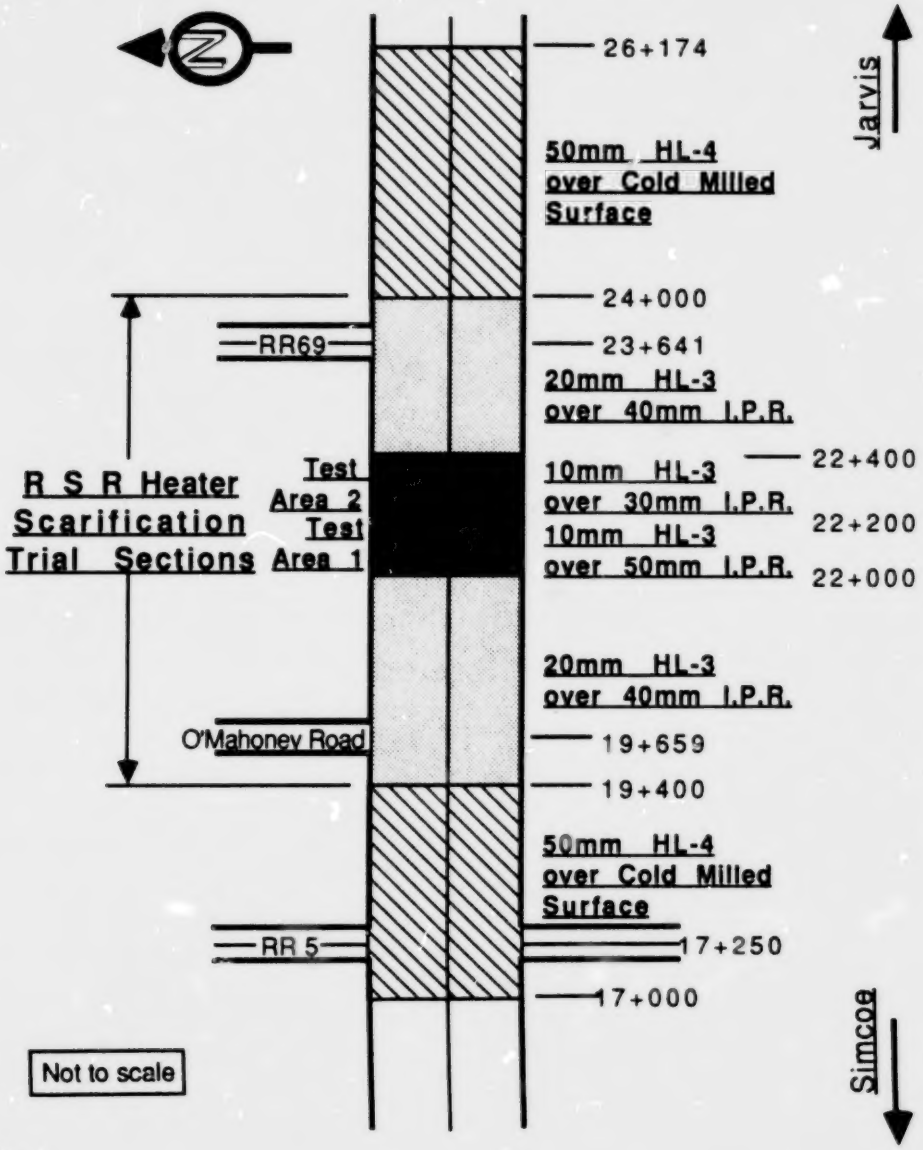
Except for two 200 m sub-sections, the in-place recycling (IPR) trial was designed for a minimum 40 mm of IPR covered by 20 mm of an integrally placed HL-3 surface course. The two sub-sections were to consist of a minimum 50 mm and 30 mm of IPR respectively, both surfaced with 10 mm of HL-3 surface course.

The IPR was to correct the cross-fall to 2.0% and place the surface mix at a uniform thickness.

The penetration of the asphalt cement recovered from the IPR was required to be between a minimum of 50 and a maximum of 80.

The intent of including the IPR in a recycling contract was to allow for direct comparison of the two recycling strategies. However, the contract allowed the prime contractor the option of retaining the reclaimed pavement and placing a HL-4 surface course. The prime contractor chose this option preciuding a comparison of recycling methods.

FIG. 1: KEY MAP, CONT. 87-08, HWY. 3, SIMCOE TO JARVIS



EQUIPMENT

The IPR train consisted of a pre-heater, the recycling / paver unit, a Dynapac CC-42A dual drum vibratory roller, followed by a Bomag BW 160 AC combination vibratory drum / rubber tire roller.

The pre-heater, as well as the heating unit on the recycling / paver unit, contained 20 burners, each rated at 350 K BTUs for a total capacity of 7 million BTUs for each machine. Both machines were variable in width from 3.04 m to 4.57 m in 0.76 m increments.

The pre-heater is intended to heat the top 12 to 20 mm of pavement to 80° C, depending on ambient conditions, and soften the pavement up to 25 mm deep.

The heaters on the recycling / paver unit are intended to raise the pavement temperature a further 40°C to 120° C for a depth of 40 mm.

The recycling/paver unit consisted of:

- a paver style front hopper for receiving hot mix from a truck,
- heater banks,
- spinners for adding a rejuvenating agent,
- retractable spring loaded cultivator tines to scarify the
- pavement and stir in the rejuvenator,
- distribution augers for the recycled mix,
- primary screed to spread the recycled mix,
- distribution augers for the virgin mix, and
- a secondary screed to place the virgin mix.

CONSTRUCTION

Temperatures

The IPR was constructed in the second half of September 1987. Temperatures were found to vary widely at the various points in the IPR mainly due to, but not restricted to, ambient conditions. Some days, the work was carried out through periodic showers.

Monitoring of temperatures on September 25 revealed the following:

LOCATION	TEMPERATURE (°C) Average	Range
Existing Surface	18	
Behind Pre-heater	35	
Recycled Mix @ Screed	105	100 - 130
Virgin Mix @ Screed	150	140 - 160
5 m Behind Screed @ E. P.	115	
50 m Behind Screed @ E. P.	75	
100 m Behind Screed @ E. P.	60	

The distance between the pre-heater and the recycling / paver unit varied but averaged about 20 m.

After one rain shower, small puddles of water were observed still existing behind the pre-heater and the mix was firm at mid lane yet loose to a depth of 30 mm ± near the lane edges.

The pavement was heated on each lane about 20 mm beyond the center-line so as to allow for scarification to center-line. Extra heat was concentrated at the center-line joint to "melt in" the longitudinal joint. This extra heat frequently caused the pavement to catch fire when the recycling / paver unit slowed down or stopped.

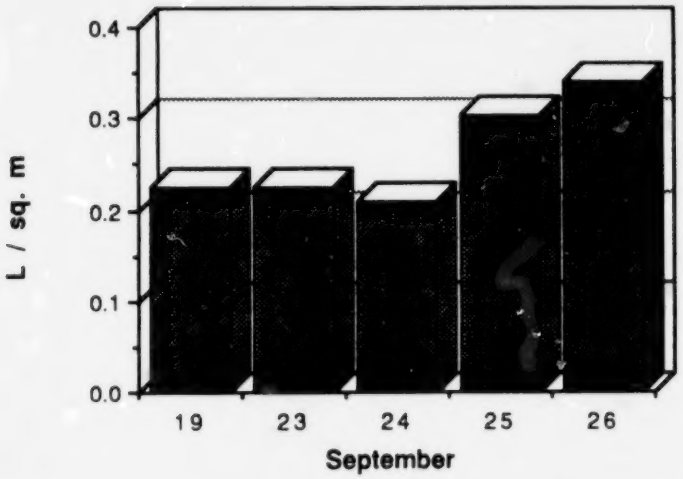
The finished mat was found to retain heat for an inordinate length of time. In fact, on the first day of operation, a cool damp day, it took two hours of cooling before one could hold a hand on the mat.

Rejuvenator

A rejuvenator made for RSR, was distributed onto the heated surface by spinners, similar to inverted lawn sprinklers which almost atomized the product. In a strong cross-wind, the product was blown down-wind, starving the up-wind side.

Addition of the rejuvenator was controlled by the operator and adjusted according to the depth of scarification. A meter read-out permitted the contractor to determine the rate of application. Figure 1 depicts the average application rate for five days of production.

FIG. 2: AVERAGE DAILY APPLICATION RATES OF REJUVENATOR



Scarification

Due to varying cross-fall and wheel track rutting, the depth of scarification also varied. Since the tines were spring loaded, they would not scarify to the desired depth when the pavement was not heated and softened sufficiently. When this occurred, (after a shower) the depth of scarification would be reduced sometimes to as little as 10 mm. The depth of scarification could only be monitored with some difficulty at the outside edges.

Distribution

The finished mat was placed level (or almost so) with the adjacent lane so as not to have a stepped longitudinal joint. This meant that the recycled material had to be moved to the outside (low side) of the lane to provide for the 20 mm virgin HL-3 overlay. Occasionally the center-line was depressed and since a 2% cross-fall was being maintained this area was deficient in recycled material and the deficiency was made up with the virgin mix. The quantity of recycled mix moved to the low side was usually sufficient to make up about two thirds of the additional 50 mm thick, 0.5 m wide partial paved shoulder. The partial paved shoulder was designed to be constructed with new mix.

The HL-3 mix quantity used was less than the design quantity by 14%. This was likely the result of using the recycled mix in the shoulder widening but could also be due to a thinner overlay being placed than the designed 20 mm.

Compaction

The breakdown roller worked to within 1 m of the screed and rolled the mat from shoulder to crown. The intermediate/finish roller followed at approximately 30 m and also worked from shoulder to crown.

Finished Work

Even though a string-line was being followed, the edges of the mat were irregular. This was likely the result of the long moment from the tow point, to the back of the second screed which would amplify small corrections in steering.

Frequent transverse bumps occurred in the mat due to such factors as; screed settlement while waiting for trucks of virgin mix, delays due to rain and equipment breakdowns. The contractor rectified these bumps with good success at the end of the project by re-heating and re-working the surface.

Productivity

Productivity was quite variable due to factors such as temperature, precipitation, truck availability and equipment breakdown. The IPR advanced at an average rate of 3 metres per minute with a range from 2 to 5 metres per minute. The average daily production over a four day period (Sept. 23 - 26) was 1.68 km of single lane construction.

Traffic Control

One-way traffic was maintained over an average 400 m by three flag persons. This length of control zone was required due to the length of the equipment train and the heat retention in the mat.

There was little inconvenience to the motoring public due to the relatively low traffic volume (4000 AADT).

ENVIRONMENTAL ASPECTS

The work was reviewed by both the Ministry of Transportation Environmental Office and the Ministry of the Environment District Office.

It was found that:

1. the visibility of motorists, passing within 8 m of the machine in the adjacent lane, was impaired by "extreme heat waves",
2. "fairly heavy smoke emission" was not excessive in this rural setting but "might be offensive in an urban area".

SAMPLING

The Contractor was required to obtain, at locations determined by the Ministry, two samples of recycled and virgin mix per km. He was further required to obtain a 4 L sample of rejuvenating agent from the delivery truck. The samples of recycled mix were obtained from the auger just ahead of the primary screed and the virgin mix from the front hopper of the recycling / paver unit. All samples were turned over to the Ministry for testing.

TESTING

Ten samples of each mix from the east bound lane were tested in the Ministry's Downsview laboratory for:

1. asphalt cement content,
2. penetration of the recovered asphalt,
3. gradation of the extracted aggregates and
4. Marshall values.

Not all the tests were performed on each sample of the virgin mix - just enough to characterize it and permit comparison to the recycled mix.

Tables 1 and 2 summarize the test values obtained.

TABLE 1: RECYCLED MIX, TEST DATA

SAMP.	A.C.	PEN.	+ 4.75 mm	+ 75 µm	VOIDS	FLOW	STAB.
1/R	5.70	25	33.2	91.0	2.7	18.0	17439
2/R	4.94	54	47.0	95.2	3.2	11.3	13642
3/R	5.07	66	43.5	95 5	2.8	11.9	13864
4/R	5.35	52	37.6	95.1	4.4	10.0	12883
5/R	5.43	25	40.2	95.3	5.2	11.8	16798
6/R	5.87	52	36.4	94.1	2.7	14.5	18293
7/R	5.37	31	35.9	93.8	*	*	*
8/R	6.12	35	40.1	95.1	2.8	15.3	18237
9/R	4.81	30	36.3	93.9	4.0	12.7	17570
10/R	5.02	32	41.2	92.9	3.5	15.4	17681
Mean	5.37	40.2	39.1	94.2	3.5	13.4	16267
St. Dev.	0.43	14.5	4.09	1.40	0.89	2.53	2164

* Not sufficient material for test.

TABLE 2: VIRGIN HL-3 MIX, TEST DATA

SAMP.	A.C.	PEN.	+ 4.75 mm	+ 75 µm	VOIDS	FLOW	STAB.
1/V		55					
2/V					3.1	10.2	11342
3/V	5.31		47.0	97.7			
4/V	4.42		55.5	98.3			
5/V	5.21		48.9	97.7			
6/V	5.69		46.7	97.8			
7/V		63					
8/V					3.3	9.8	12135
9/V	5.08		44.9	97.2			
10/V	4.65		54.2	97.7			
Mean	5.06	59.0	49.5	97.7	3.2	10.0	11739
St. Dev.	0.46	5.7	4.33	0.35	0.14	0.28	561
TARGET	5.30		45.0	97.3	3.1	9.2	9700

The average test values for the IPR, with the exception of the penetration, suggest that a good mix was achieved. The variability of asphalt cement and + 4.75 mm content is higher than would normally be expected with a virgin mix. Only 40% of the samples met the requirement for penetration of the recovered asphalt. The range of penetration results from a low of 25, (the original condition) to a desirable 66 is unacceptable. The mean penetration value of 40 is estimated to be equivalent to a 5 to 10 year old pavement.

The test results on the virgin HL-3 asphalt cement and + 4.75 mm content is also more variable than would be expected. This variation is likely the result of segregated samples due to the method of sampling. Samples obtained from the side of the front hopper of a paving machine are likely to be stony due to roll-out of the coarse aggregate as the load is dumped. Samples 4V and 10V, with their high + 4.75 mm and low asphalt cement content are classic examples of a segregated sample. The mean asphalt cement and + 4.75 mm content are likely biased due to this factor.

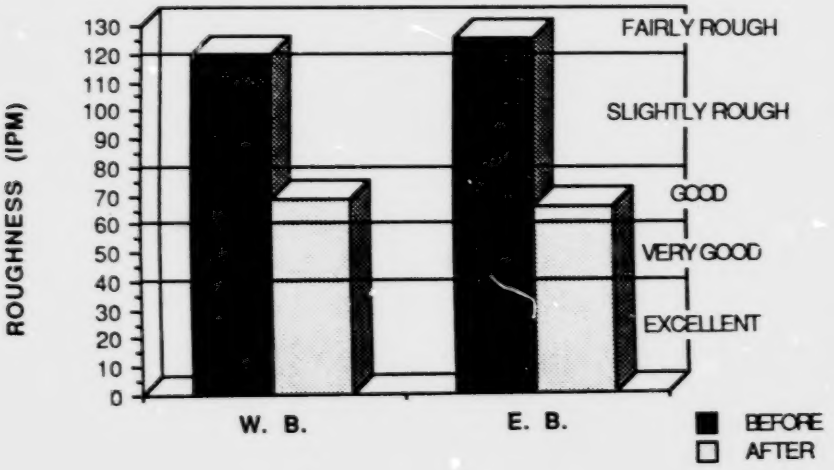
The Ministry normally obtains samples of hot mix by paving over a steel plate template and then lifting it out of the mat as a full depth sample. This method yields a representative sample of what was placed on the road. Unfortunately this is precluded with IPR due to the nature of the operation.

Test results of asphalt cement content or gradation of the extracted aggregates of samples obtained from the paver hopper or screed augers are suspect. Test results on the penetration of the recovered asphalt should be considered valid, since segregation of the mix has no influence on these results.

The stability data for both the IPR and virgin mix are higher than actual due to the reheating of the mix in the laboratory.

Roughness measurements were taken both before and after construction with a Mays Ride Meter which records roughness in inches per mile (IPM). The results of the roughness survey are presented in Figure 3. The "after" roughness results on the control sections on both ends of the IPR were virtually the same as for the IPR.

FIG. 3: MAYS METER ROUGHNESS SURVEY



DISCUSSION

The demonstrated advantages of in-place recycling over cold milling and recycling through a central hot mix plant were:

1. no cold milled surface to maintain traffic on,
2. no stepped longitudinal or transverse joints,
3. little or no degradation of aggregates in the mix,
4. low operational noise level,
5. little or no debris to remove and
6. only a one-time disruption to traffic.

The disadvantages were:

1. the designed depth of scarification was not maintained,
2. difficult to determine actual depth of scarification,
3. the addition of recycling agent was variable and often inappropriate for the depth of scarification,
4. the penetration of the asphalt cement in the recycled mix was unacceptably low,
5. heat waves and smoke restricted motorists visibility.

The performance of the trial will be monitored on an ongoing basis.

REFERENCES

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